Impact of lithium-coated walls on plasma performance in the TJ-II stellarator

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Oulook

- Introduction
- Lithiumization of TJ-II
- Particle control
- Impurity behavior
- NBI plasmas
- Conclusions

Introduction

Plasma Wall Interaction in Stellarators:

+ No disruptions, no Type I ELMS, no density limit (Greenwald..), intrinsic divertor…

- Larger aspect ratio...smaller <a> for given volume:

-Higher S/V ratio

-Higher λ_{iz} /a ratio

+ Impurity accumulation

Lithium in Tokamaks

Why Li?

- Very low Z
- High impurity getter (O_2,N_2,CO, H_2O,CO_2…)
- Strong H retention (LiH)
- Low melting point: Liquid PFC
- Effect on C sputtering OK (H. Sugai, JNM 1998)

Very good results in Tokamaks:

TFTR, CDX-U, FTU, T-10, T-11M….

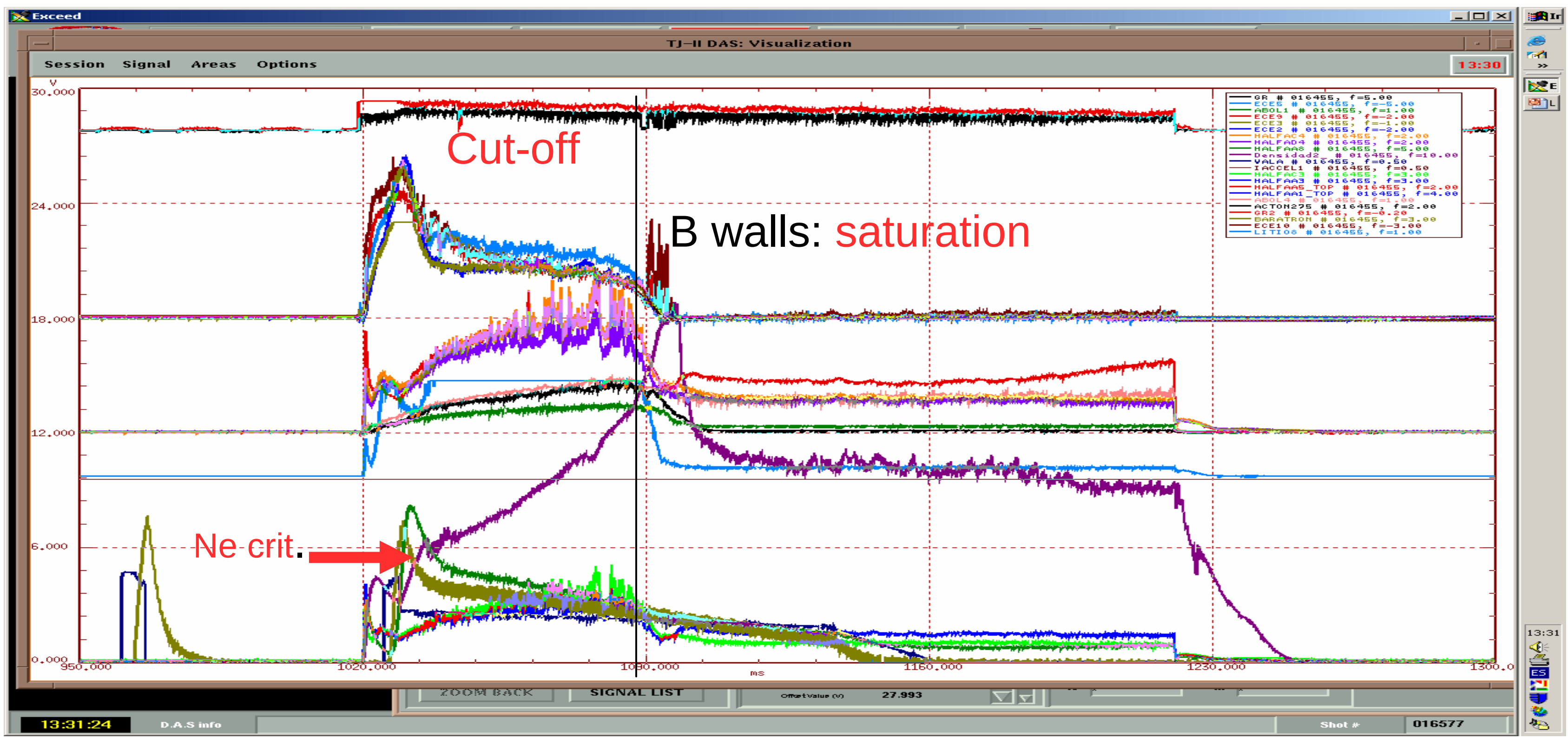
Different ways of deposition; Liquid tray, pellets, LLL, CPS, evaporation……

But : problems in reproduce beneficial effect: Total coverage??

Wall Conditioning in TJ-II

-Metal walls +He GD+Ar GD: He release, Enhanced Particle Confinement transition (EPC, F.L. Tabarés et al PPCF 2001)

-Boronization; O-carborane+He GD: wall saturation (<20 discharges)+ EPC



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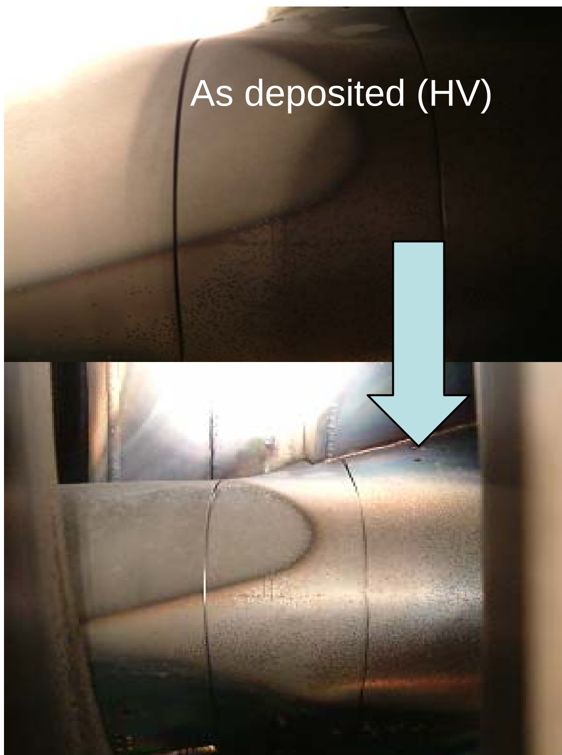
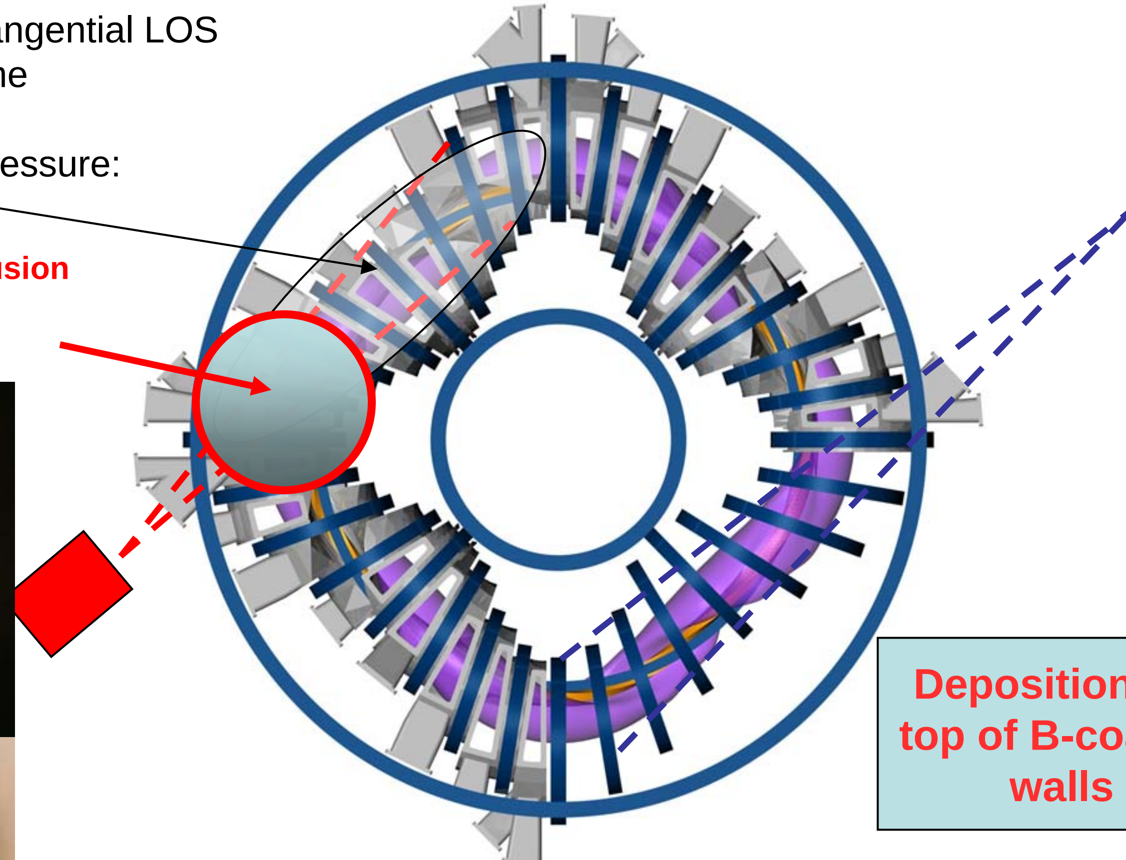
Lithium coating in TJ-II

How?

- **4 ovens**, symmetric,tangential LOS
- 4 g deposited each time

- Role of background pressure:
  - **- HV: line of sight**
  - **- 10^{-3}-10^{-5}mbar: diffusion**
  - **- Ne GD+ ovens**





Deposition on top of B-coated walls

Re-distribution by plasma: Improving with operation time!!

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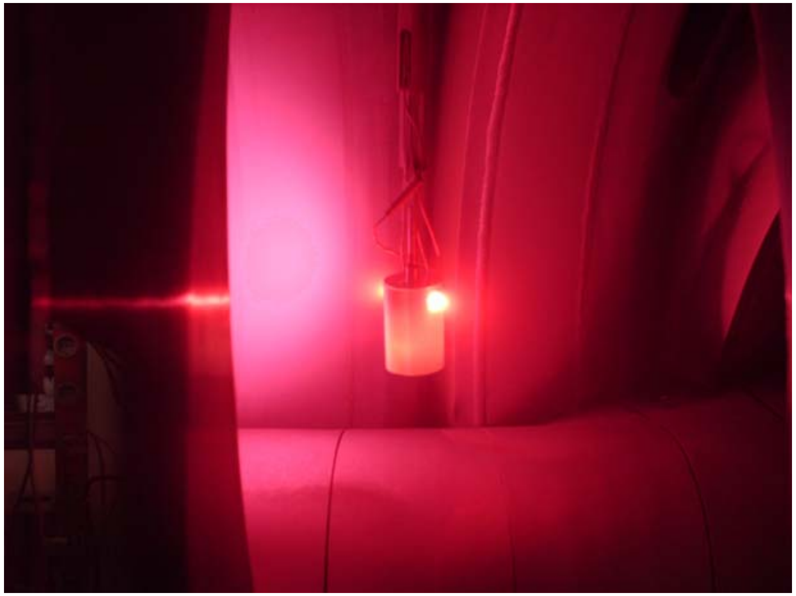
Li Coating Technique

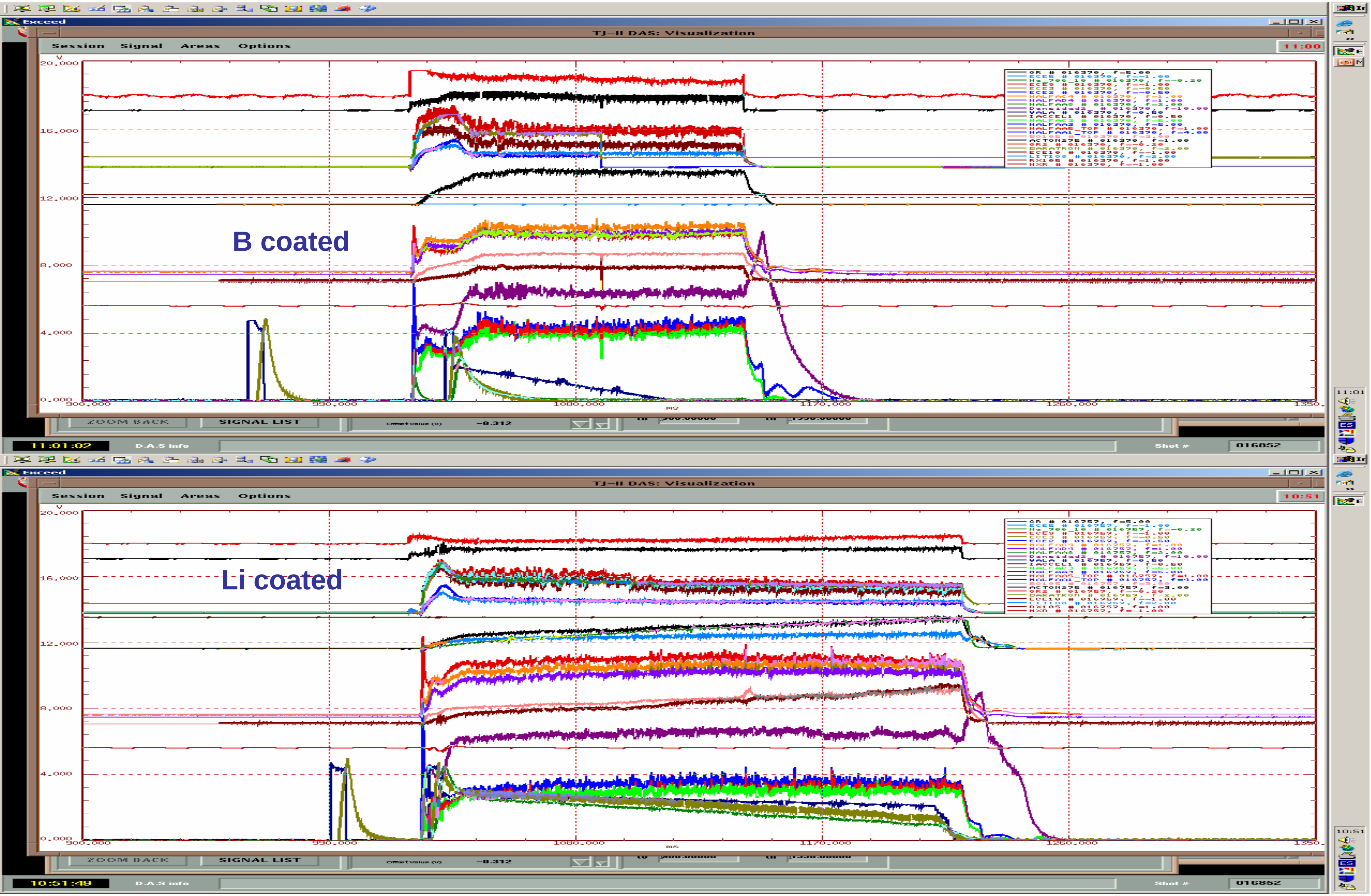
4 Lithium ovens: 2 fixed (side windows) and 2 in retractable manipulators (top windows)



Emission of Li injected from a retractable oven

1 gr of Li per oven, heated to ~600 ºC during Ne GD

Impact on plasmas



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Particle Control Li vs B

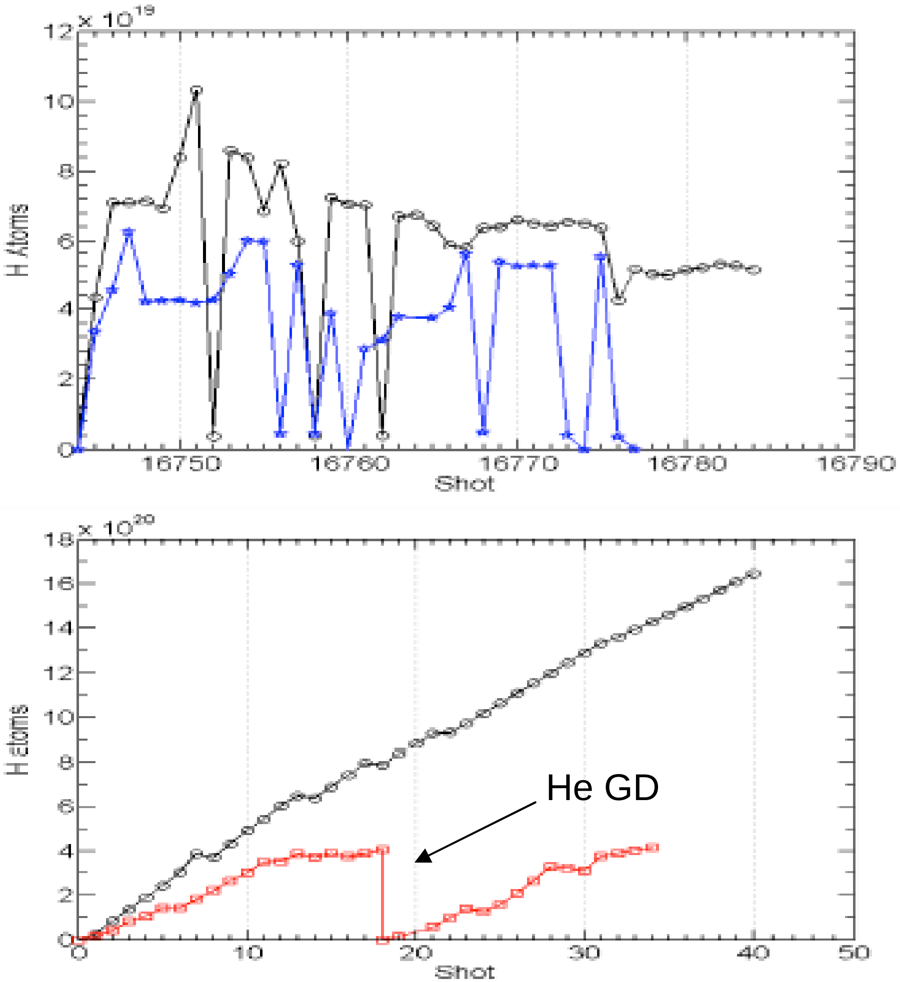


Fig.1. Particle balance under B and Li wall conditions. Top: integrated particle injected per pulse. Bottom. Cumulative retention of H in the walls. Black, Li. Blue and red, B.

Factor 2-4 more gas required for similar densities in Li walls

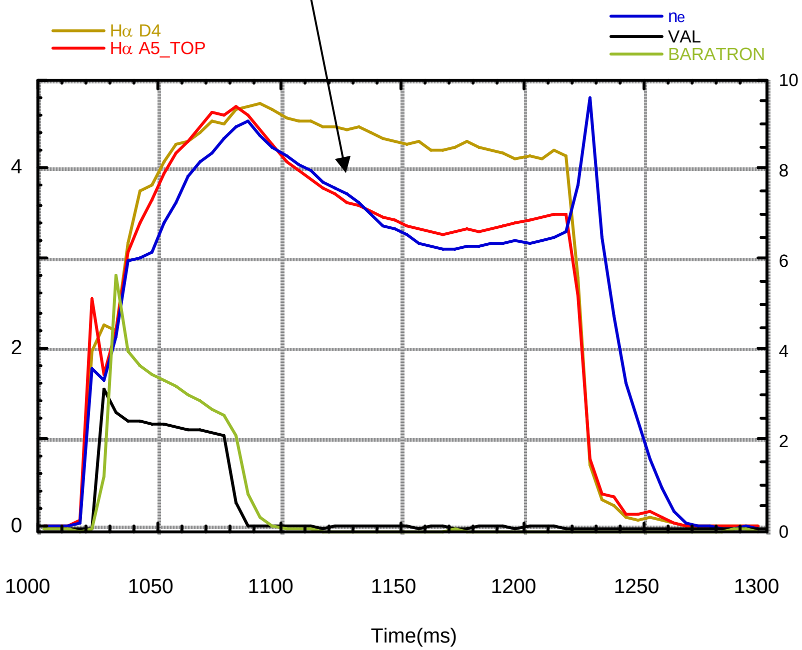
Total wall inventory > 4times, no sign of saturation

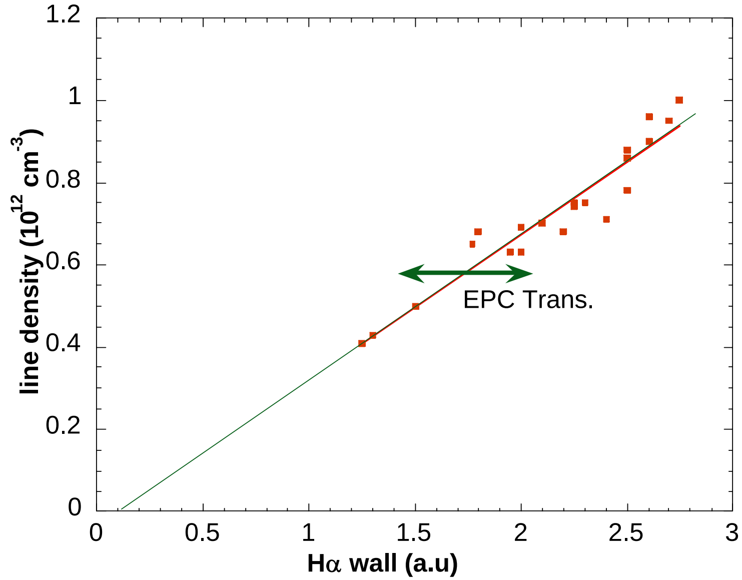
Dynamic particle balance

For ECRH plasmas: $dN/dt = f.\ Qin - N/(\tau p/1-R)$

Always in the EPC mode?

f ~1, $\tau_p$eff ~30 ms, R~0.6-0.7





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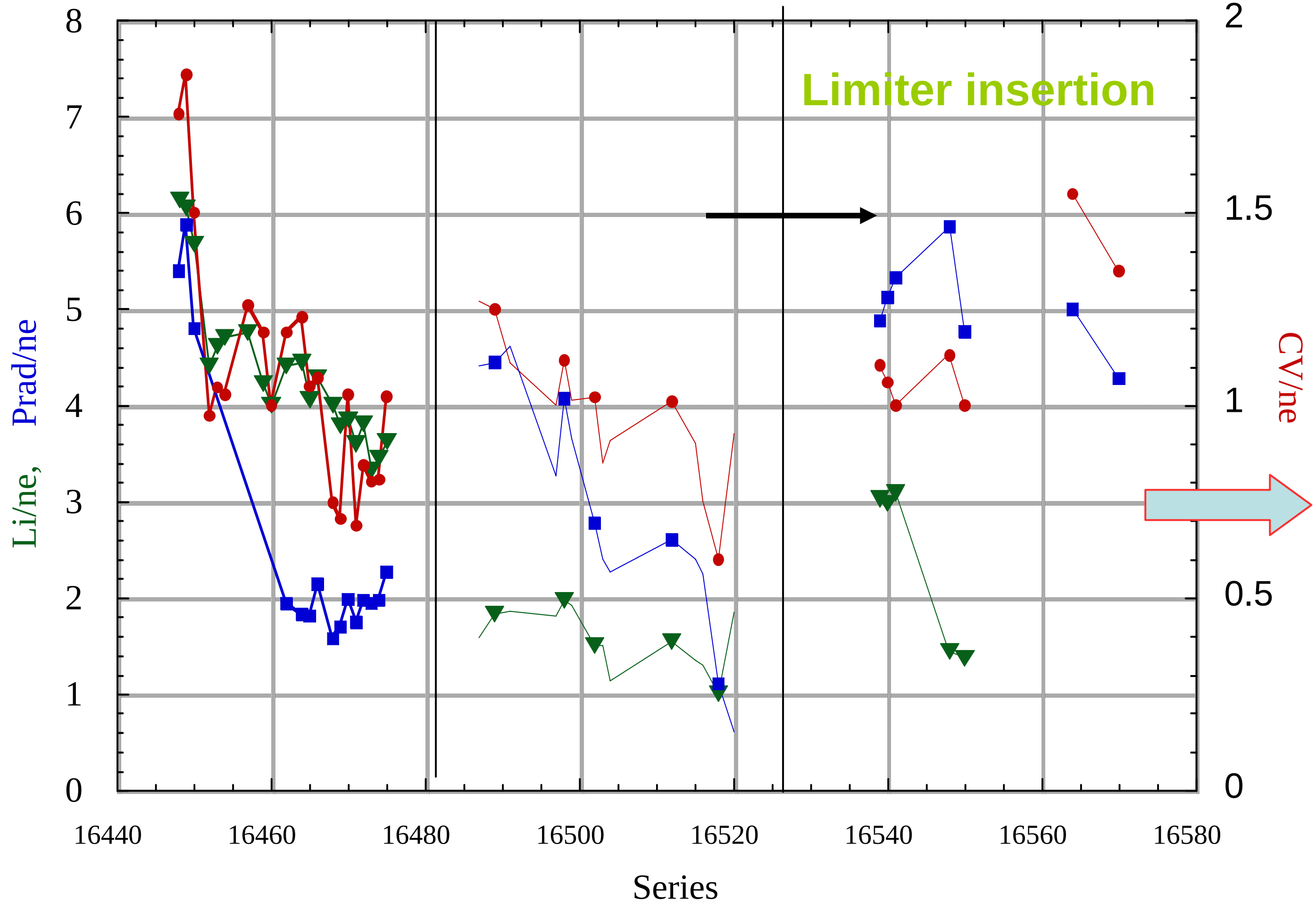
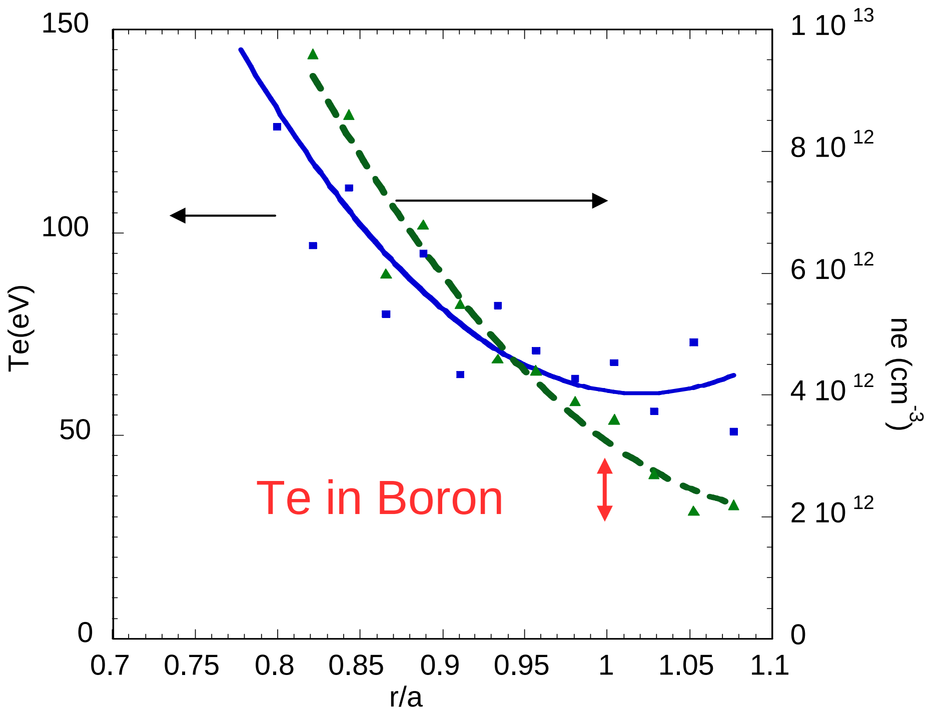
Impurity behavior

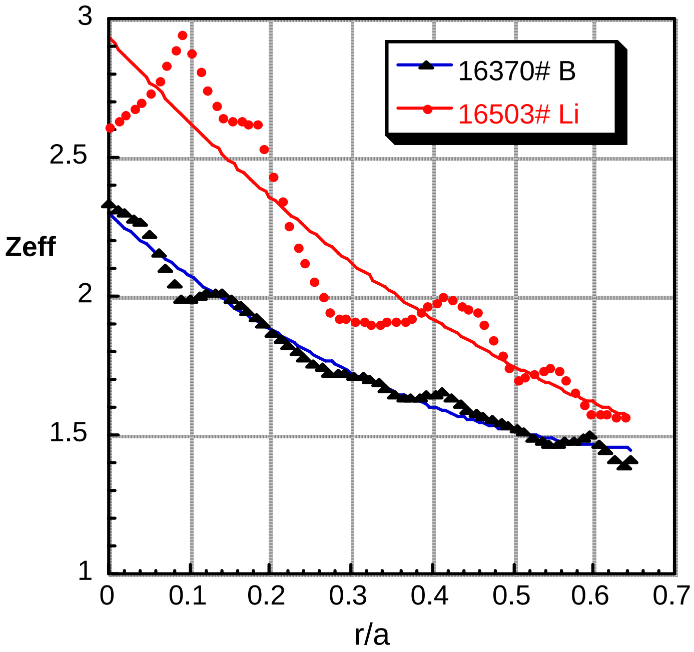


New Li depos.

Impurity behavior



Hotter edge, similar density



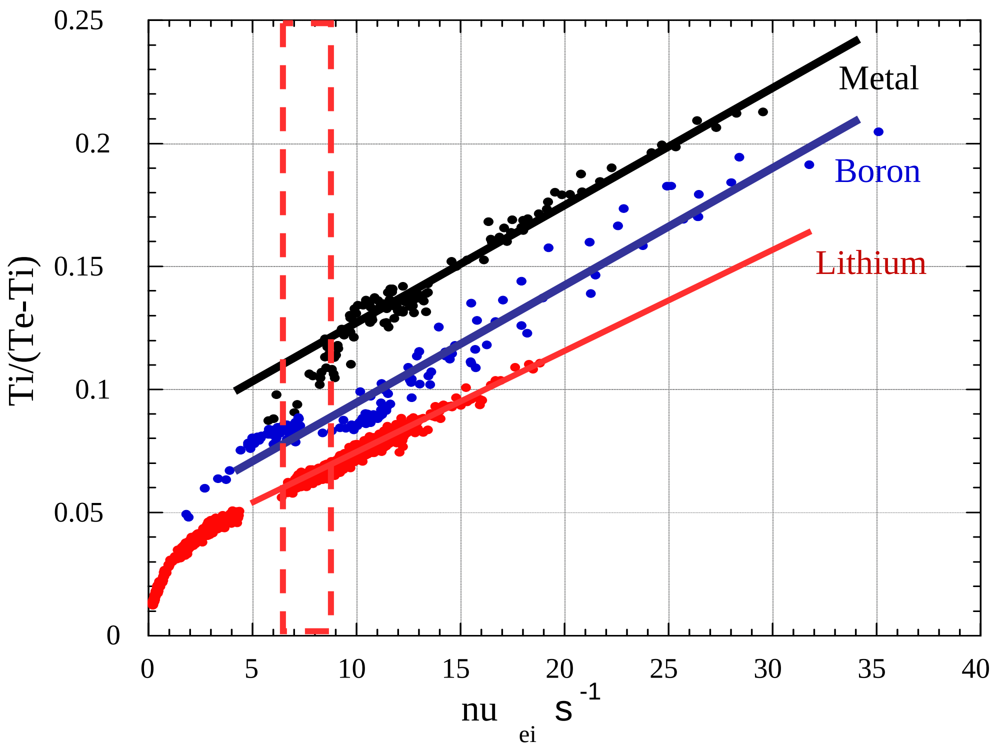
Higher central Zeff?

Ion confinement

- Similar Ti in ECRH plasmas, but higher Te(0)

$\nu_{i-e}.\Delta T_{i-e}.ne- (Ti/\tau_i+K_{cx}n_0Ti).ni=0$, for high ν_{i-e} , CX losses neglected

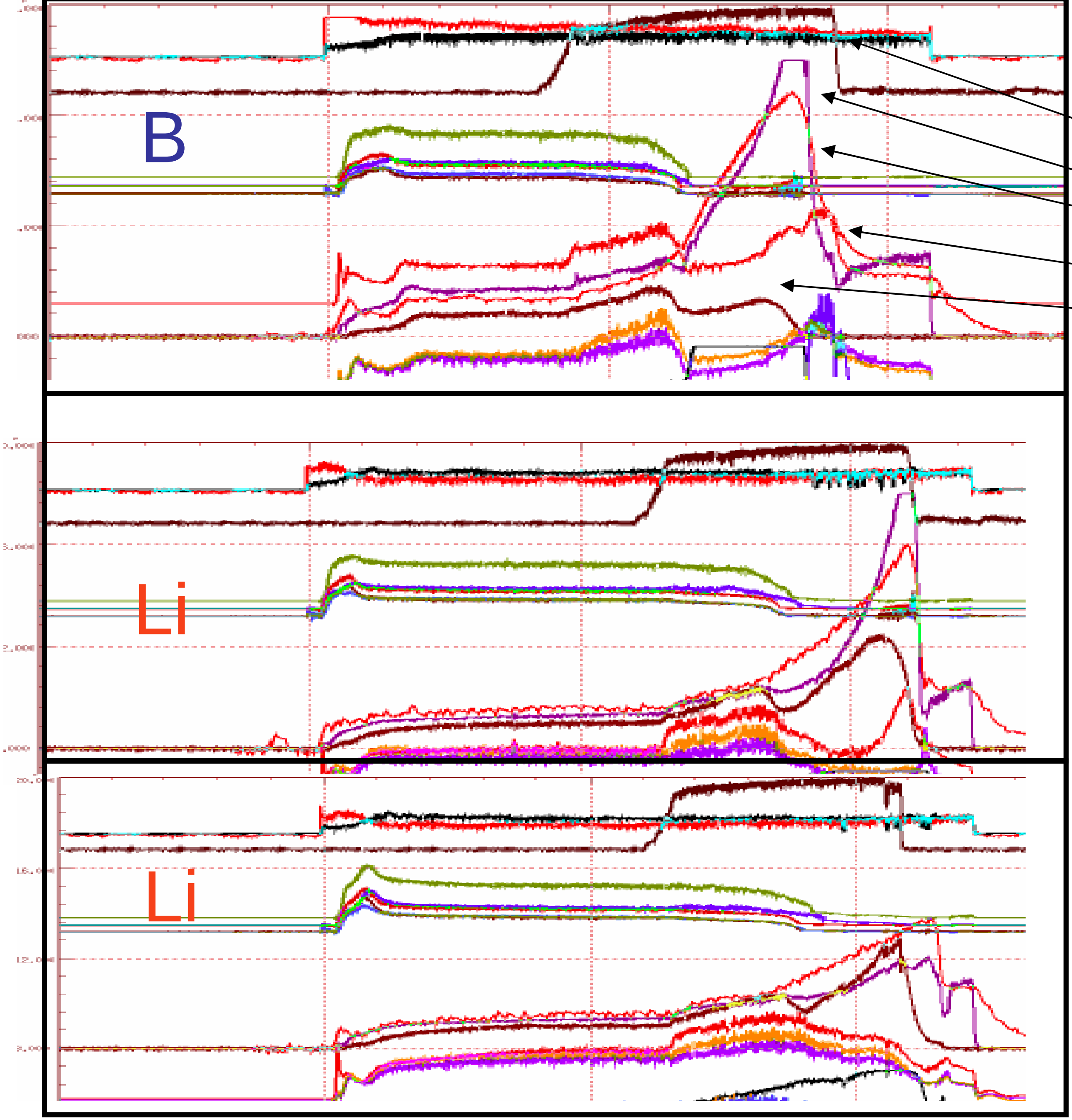
EPC Critical collis. (Guimaraes et al, P2-014), shear layer develop
(Pedrosa O-03,P2-012…)



•Similar τ_i

•No discontinuity at critical collision frequency (EPC aborted?)

NBI plasmas



I accel
P rad
Ne
HaNBI path
SXR
Ha wall

No density roll-over
High SXR in NBI phase

Lower dN/dt

Full duration

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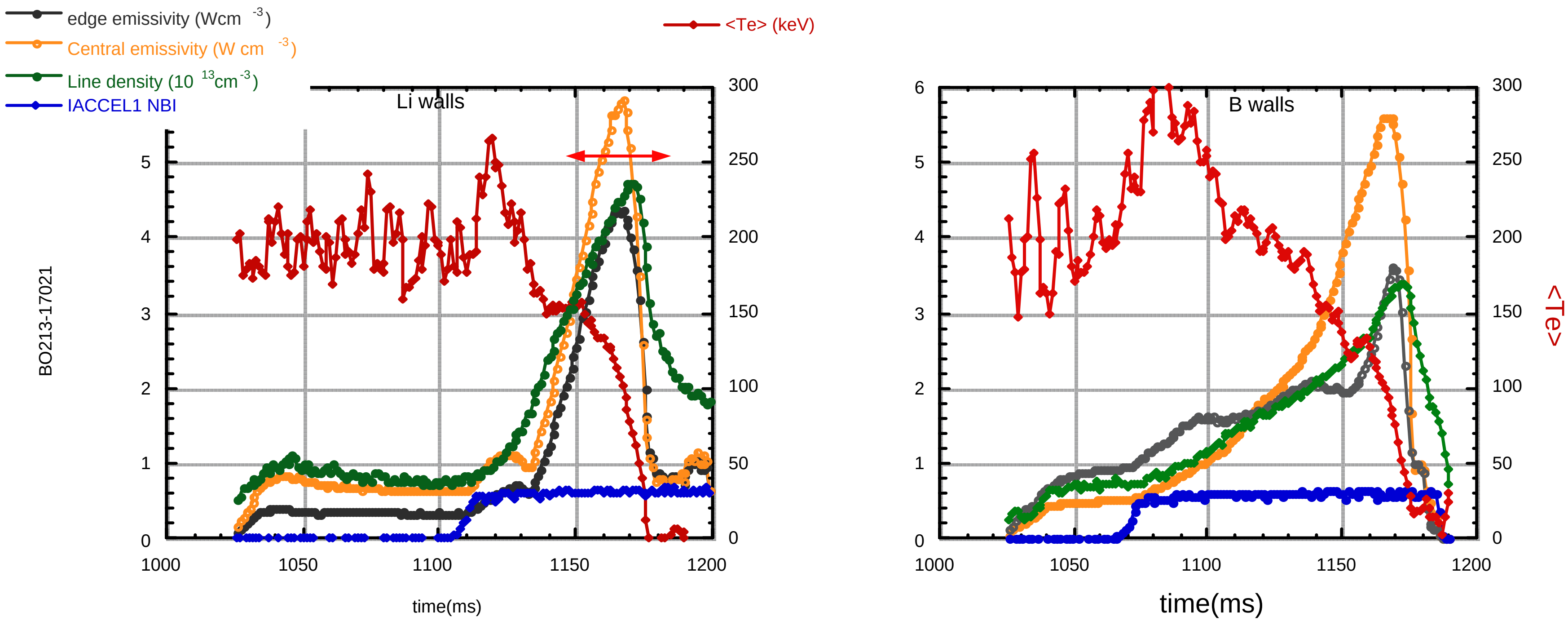
NBI Plasmas



- **Density control:** Still limited by density ramp up: NBI fuelling enhanced by PWI, but lower dN/dt obtained in Li
- **Record density and W dia** at collapse obtained in Li walls
- Strong change of edge/core radiation ratio: Thermal vs radiative collapse(?) (M. A Ochando et al Nucl.Fus.1997

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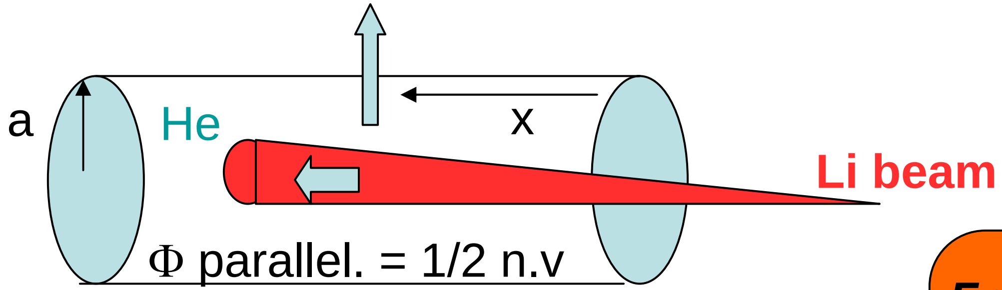
System Upgrade

Searching for homogeneity:

-8 ovens, loaded for repetitive, in situ evaporation (6-8 cycles)

- Diffusion can help:

Φ dif.= 1/3 λ.v.n/a, λ @10^{-5} mbar He ~80cm



$n(x) \sim 1/x^2 . \exp(-x/\lambda)$

$\mathbf{\Phi_{diff}(x) = n_0 \exp(-x/\lambda)/\lambda . 2\pi a, \lambda \sim 1/P_{He}}$

Free **Parameters:**
-Type of gas
-Bkgnd pressure
-Distance between ovens

Long term: LLL in TJ-II(?)

Conclusions

•Li coating by evaporation was performed in TJ-II.

• Only a partial coverage initially achieved, but evolved with plasma interaction

• Machine operation more reliable and reproducible

•Density control highly improved, long lasting effect

• Strong change in particle recycling

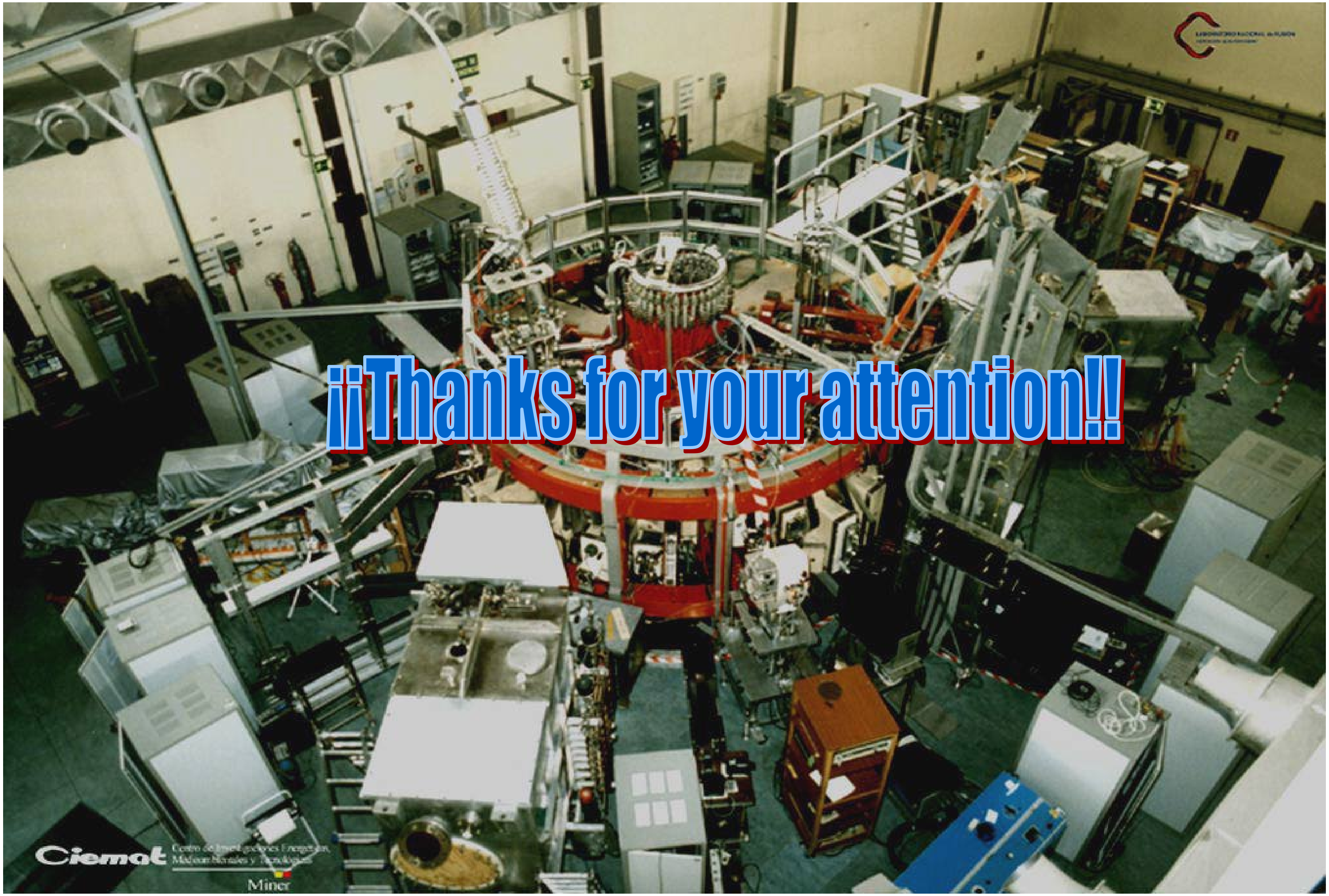
• Good impurity control, but hotter edge problematic if C(Me) is exposed to the plasmas: homogeneity problem?

• No major changes in confinement, but transition to EPC hindered

• Better control of NBI plasmas, but still to improve

• Change in radiation profiles may prevent radiation instability-driven collapse

• Improvement of technique in progress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